DOCUMENT RESUME

ED 075 075 PS 006 410

AUTHOR Mandler, Jean M.; Stein, Nancy L.
TITLE Recall and Recognition of Pictures by Children as a Function of Organization and of Distractor Similarity.
INSTITUTION California Univ., La Jolla. Center for Human Information Processing.
SPONS AGENCY National Inst. of Mental Health (DHEW), Bethesda, Md.; San Diego Unified School District, Calif.
REPORT NO CHIP-32; TR-32
PUB DATE Jan 73
NOTE 35p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Children; Organization; *Predictive Validity; *Recall (Psychological); Recognition; Stimulus Devices; Technical Reports; Verbal Stimuli; *Visual Stimuli
IDENTIFIERS *TORSCA Multidimensional Scaling Technique

ABSTRACT

Verbal description, recall, and recognition of complex meaningful pictures by children were studied, varying amount of stimuli and similarity of distractors. Across subjects (sex, ethnic group, and grade level) verbal measures were poor predictors of recognition accuracy. Across stimuli, amount recalled and recognition accuracy were both related to amount of organization. Recognition was also a function of the type of transformations on the target that were used as distractors. For all transformations there was a close match between ability to recognize a transformation and judgment of dissimilarity of the transformation to the target. The TORSCA multidimensional scaling technique was applied to the similarity judgments to obtain a representation of a memory space for the targets and their transformations. The structure of this space was highly consistent across subjects and indicated that transformations on meaningful pictures can be related to each other in stable ways. (Author)

U. S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

ED 075075

CHIP Report 32

January 1973

RECALL AND RECOGNITION OF PICTURES BY CHILDREN AS A FUNCTION OF ORGANIZATION AND OF DISTRACTOR SIMILARITY

Jean M. Mandler

University of California, San Diego

and Nancy L. Stein

Washington University

Technical Report No. 32

Center for Human Information Processing

Department of Psychology

University of California

La Jolla, California 92037

PS 006410

FILMED FROM BEST AVAILABLE COPY

RECALL AND RECOGNITION OF PICTURES BY CHILDREN AS A FUNCTION OF ORGANIZATION AND OF DISTRACTOR SIMILARITY

Jean M. Mandler and Nancy L. Stein

University of California, San Diego Washington University

Abstract

Verbal description, recall, and recognition of complex meaningful pictures by children were studied, varying amount of organization in the stimuli and similarity of distractors. Across subjects (sex, ethnic group, and grade level) verbal measures were poor predictors of recognition accuracy. Across stimuli, amount recalled and recognition accuracy were both related to amount of organization. Recognition was also a function of the type of transformations on the target that were used as distractors. For all transformations there was a close match between ability to recognize a transformation and judgment of dissimilarity of the transformation to the target. The TORSCA multidimensional scaling technique was applied to the similarity judgments to obtain a representation of a memory space for the targets and their transformations. The structure of this space was highly consistent across subjects and indicated that transformations on meaningful pictures can be related to each other in stable ways. Location of transformations within the space was related to type of picture and amount of organization in the picture.

RECALL AND RECOGNITION OF PICTURES BY CHILDREN AS A FUNCTION OF ORGANIZATION AND OF DISTRACTOR SIMILARITY[1]

Jean M. Mandler[2] and Nancy L. Stein

University of California, San Diego Washington University

Investigators exploring the visual memory systems of both adults and children (Shepard, 1967; Standing, Conezio, and Haber, 1970; Brown and Scott, 1971) have shown that once subjects are exposed to pictorial material, their ability to recognize previously seen pictures is extremely good. Standing et al (1970) presented 2560 pictures and found a hit rate for old pictures of .95 or better. Haber (1970) has suggested that picture recognition may be essentially unlimited, and has contrasted it with recognition for verbal materials. "Unlimited" is perhaps too strong a term, however, since several variables are known to affect accuracy of picture recognition.

1) Similarity of distractors to target. Recognition of pictures of single objects is directly related to similarity of the distractors, when the latter are scaled along a single "similarity" dimension (Bahrick, Clark, and Bahrick, 1967). When more complex pictures have been studied, however, few experiments have systematically manipulated this variable. Most studies have used a random selection of distractors, chosen from the same modality as the target items (e.g., photographs) but with content uncontrolled. One study which used similar distractors (Dallett, Wilcox, and D'Andrea, 1968) found somewhat lower recognition rates, ranging from .69 to .85, but no attempt was made to define or scale degree of similarity. Brown and Campione (1972), working with children, studied a single dimension of

similarity by using distractors which varied from the targets only in the type of action a central character performed. Immediate recognition averaged around 95%. Thus, for adults, recognition accuracy is affected by similarity of distractors, but there are not enough data to know whether this is as true for children. In addition, little is known about the dimensions along which children scale similarity of remembered pictures to distractor items.

2) Organization of the stimulus materials. Organization of a picture is defined here by the relations among its various parts and is equated with the concept of meaning (see Garner, 1962). Adults recognize pictures of faces better than ink blots (Goldstein and Chance, 1971), and children recognize meaningful pictures better than abstract or nonsense pictures (Nelson, 1971). However, little is known about the effects of higher levels of organization on recognition, namely, the relationships within a picture among parts which are themselves meaningful, such as are usually found in complex pictures.

It seems likely that judgments of similarity will vary with the amount of organization in a picture. There is little information on this problem, yet it seems reasonable to assume that the more information which is organized into a single chunk (or picture) the less likely it is to be confused with another chunk containing an equal amount of different information. Thus, if complex pictures do contain a very large amount of both visual and semantic information, it is probably the case that the pictorial distractors used in experiments such as that of Standing et al (1970) were grossly dissimilar from the target items. This brings us to the third variable known to affect accuracy of picture recognition.

3) Verbal or semantic information. Several studies have assumed that using pictorial distractors which have the same verbal label as the target

pictures will increase distractor similarity and therefore decrease recognition. In two studies with children this was not the case; accuracy increased under this condition (Rozinski, 1970; Brooks, 1972). A decrease in recognition accuracy has been reported with adults, however (Bahrick and Boucher, 1968). Further, verbal labels attached to a geometric form have been shown to produce systematic changes in recognition accuracy along a continuum of physical similarity (Daniel, 1972). Clearly, one of the primary problems facing the investigator who is interested in recognition of meaningful pictorial materials by children or adults is the relation of purely visual dimensions, such as size or shape, to the semantic dimensions of pictures. For example, we do not know whether changes in orientation, deletions, or substitutions, affect recognition of meaningful collections of objects in picture form in the same way as they do for geometric shapes.

The present experiment investigated several of these aspects of picture recognition in children. The degree of organization of complex pictures was varied as well as the similarity of distractor items. Distractors were constructed by making minor transformations on the original pictures. Two recognition tests were used, one of which measured recognition accuracy; the other required judgments of similarity of the various transformations to the remembered pictures. Multidimensional scaling techniques were used to construct dimensions of similarity of the various transformations to the originals.

In addition, verbal description and verbal recall of the pictures were studied. Children tend to be poorer on verbal recall than adults, yet to the extent that it has been studied, show equally good recognition of pictures. In addition, children of different ages and ethnic groups vary in amount of

verbal description of pictures (Heider, 1971) and verbal recall (Jensen, 1971), but there is essentially no information on how these differences relate to recognition ability. To study this problem, children from two grades and three ethnic groups were used to compare description, recall, and recognition of complex pictures.

Method

Subjects

Because extensive verbal and recognition data were collected, a large number of Ss was used, each working with only two target pictures, rather than a smaller number of Ss, each viewing many pictures. Ss were 168 children from the San Diego Unified School District, divided into groups by sex, ethnic group (Black, Chicano, and Anglo) and grade level (grades one and two). Chronological age in the first grade ranged from 6.2 to 7.1 years, mean = 6.75, and in the second grade from 7.2 to 8.3 years, mean = 7.8). Most of the children were taken from one school, located in a borderline lower to middle SES area, which was composed of a fairly even mix of the three ethnic groups. There were not enough Black children to complete the sample, and slightly less than half of the second grade Black sample was drawn from another school from a lower middle SES area. Children with any known neurological or psychological disorders were excluded from the sample.

Stimuli

Two sets of 8 1/2 x 11 inch black and white line drawings were used; each set contained one "organized" and one "unorganized" picture. Within a set the organized and unorganized pictures contained the same objects. In the organized version a naturalistic scene was created, using familiar relationships among objects. In the unorganized version the same objects were placed in an unrelated array. The four pictures are shown in Figure 1.

The pictures were constructed during pilot testing. Easily recognizable objects with a considerable amount of detail were drawn by two amateur artists. Final selection was made on the basis that the various objects could fit into a "realistic" scene and that in the pilot group children from the same ages and ethnic groups used in the study could appropriately label all objects and details. A rough attempt was made to equate number of objects in the two sets of pictures. However, it is recognized that the pictures vary in a number of ways, such as saliency and location of items, likely focus of attention, etc. Since one of the aims of the study was to explore general factors in pictorial memory, it was decided not to attempt to equate the pictures in any more precise way.

Five transformations were used for each of the pictures: 1) Reversal: A left-right mirror image of the Original. 2) Deletion: Three items were deleted from the Original, ranging in size from a small detail to a small object. In the Bus pictures (see Figure 1) the girl's purse, the chimney on one house, and one of the books was deleted. In the Lady pictures, the pendulum of the clock, one of the flowers on the table, and the pair of shoes were deleted. 3) Size change: One item was made larger or smaller. In the Bus pictures the bus was made fifty percent smaller. In the Lady pictures the vase with flowers was made fifty percent larger. 4) Rearrangement: The location of one item was changed. In the organized Bus picture the jacket on the hanger was moved from the right to the left of the table; in the unorganized version the positions of the jacket and the dog were exchanged. In the organized Lady picture the shoes were moved from under the table to the right of the table; in the unorganized version the positions of the shoes and the car were exchanged. 5) Substitution: One object was

PS 006410

replaced by a conceptually similar object. In the Bus pictures the bowl of fruit was replaced by a basket of fruit. In the Lady pictures a different type of clock was used.

Design

The 168 Ss were divided into the three ethnic groups of 56 Ss each. The ethnic groups were further subdivided into equal numbers of boys and girls in the first and second grades. Within each of these twelve groups each child worked with two pictures, an organized picture from one set and an unorganized picture from the other. Order of presentation (Organized first or Unorganized first; Bus first or Lady first) was counterbalanced across groups. Presentation order was not a significant variable in any of the analyses and will not be discussed further.

For each of the pictures shown to a child, four tasks were given in a constant order: 1) Verbal description of the picture while viewing the stimulus. 2) Verbal recall of the picture. 3) Same-Different recognition test, in which Ss were presented with the five transformations and the Original in a random sequential order Ss were required to respond to each presentation by saying whether the instance was exactly the same as the Original or whether it was different. If the child responded "Different" he was asked to tell how it was different. 4) Paired-Comparison recognition test. A two alternative forced choice procedure in which each transformation and the Original were paired with all other transformations to make fifteen pairs of pictures. S was asked to pick one picture from each pair which looked most like the original picture he had seen and described.

Procedure

The Raven's Colored Progressive Matrices test was administered individually before the experimental procedures began. Then each S was tested

individually in two experimental sessions one week apart. In each session one target picture was used. At the beginning of the first testing session S was told that his voice would be recorded and that he would be allowed to listen to his voice. Then he was told he was going to see some pictures and that E wanted to see how children looked at pictures and remembered them. Ss were assured that the testing procedure had nothing to do with grades or school work. When E felt that some rapport had been gained and S was reasonably relaxed, the experimental procedure began.

1. Description. S was given a practice picture which was rich in detail and similar to the experimental pictures. S was asked to tell everything he saw in the picture, no matter how small the detail, and to leave nothing out. He was asked to point to each object or detail as he mentioned it. If S had any difficulty with the describing and pointing procedure, E demonstrated what was required. The practice picture was kept in front of S until he described most of the details in the picture.

After this preexperimental procedure, S was given the first experimental picture and the description and pointing instructions were repeated. Presentation time was three minutes. If S responded incompletely or stopped too soon, E prompted him by asking if he saw anything else. At the end of three minutes, E flipped the picture over and talked to S for 20 sec.

2. Recall. S was next asked to recall as many objects and details from the picture as he could remember. When he stopped the first time, E prompted him once. If he could not respond the recall task was ended; otherwise it continued until he stopped the second time.

3. Same-Different task. Approximately 30 sec after the recall task, S was presented with six pictures in sequence, five of which were transformations of the original picture, and one of which was a copy of the original.

S was told that he would see six pictures, some of which were exactly the same as the picture he had just described and recalled, and some of which were different. If a picture was exactly the same, S was to say "Same." If different, S was to say "different" and tell exactly how it was different. A different sequential order of pictures was used for each child in a Latin Square design.

4. Paired-Comparison task. After a short break of approximately 30 sec S was told he was now going to see pictures two at a time. Each time a pair was presented he was to choose the picture which looked most like the original picture he had described and recalled and which was still lying face down on the table. He was told further that if neither picture looked exactly like the original picture he was to choose the one which looked most like the original. S was then presented all combinations of target and transformations, two at a time. Presentation sequence was randomly chosen for each S.

The second session was identical to the first, except that the practice picture was not presented.

Results

Verbal Description and Recall

Verbal description and recall measures are summarized in Table 1. The first column shows the main description score, consisting of the total number

---

Table 1 about here

---

of items mentioned (either whole objects or details). Inferential statements

(e.g., the girl is happy) and relational statements (e.g., the bowl is on the table) as well as repetitions were scored separately and not counted in the main description score. These measures are shown in columns two and three respectively. Similar analyses were carried out for verbal recall, shown in columns four through six. Two other recall measures were computed: the percent of items in each S's description that also appeared in his recall, and the percent of items in recall that had not been mentioned in that S's description. These measures are shown in the last two columns. Analyses of variance (3 subject variables x 2 stimulus variables) were carried out on the various verbal measures. Significance levels for the analyses are also shown in Table 1.

Subject variables. 1) Grade. There were no main effects on any verbal measure due to grade level. 2) Sex. Males had higher description and recall scores than females. Interactions with grade level on number of items in description ($p < .05$) and in recall ($p < .01$) showed that this effect was due primarily to the second grade boys, who described and recalled significantly more than the other groups. 3) Ethnic Group. Anglos both described and recalled more than Blacks, who in turn described and recalled more than Chicanos.

Stimulus variables. 1) Organization. Degree of organization of the pictures did not affect amount of description but did affect amount of recall. Organized pictures produced a greater number of items recalled than Unorganized pictures. 2) Picture Set. The Bus pictures produced more items in description than the Lady pictures, but there was no significant difference in amount of recall of the two kinds of picture.

Number of inferential and relational statements was small in comparison with number of items mentioned, perhaps because of the type of instructions given and the pointing method of description used. The two types of statements were combined into a single measure for purposes of analysis. In general, scores on this measure paralleled the total description and recall scores, males making more inferential and relational comments than females, and Chicanos making fewer than Blacks and Anglos, who did not differ from each other. There was a significant interaction between grade level and sex on this measure. Boys increased the number of such statements over grades, whereas girls decreased ($p < .001$). Similarly, Blacks and Chicanos increased the number of such statements in the second grade, whereas Anglos decreased ($p < .001$). Further work would be required to determine whether these differences in relational and inferential statements among groups were due to different verbal styles or different understanding of the requirements of the task.

Repetition of items occurred fairly frequently in both description and recall. There were no instructions that the Ss should not repeat themselves, but these data may be contrasted with the lack of repetitions, also without instructions, found in adult recall of verbal material (Borges, 1972). There were no significant differences in amount of repetition in description and recall as a function of stimulus variable, and the only subject variable affecting repetition was Ethnic Group. Blacks repeated items more than Anglos, and Chicanos had very low scores on this measure.

There are several ways in which recall might be expressed in relation to description. Column 7 of Table 1 shows the percent of items described that were also recalled. The mean for the total sample on this measure was

54%, a score high in comparison with immediate recall of well organized lists of words (Mandler, Pearlstone, and Koopmans, 1969). However, recall can also be represented as a percentage of total number of items described by the subject pool. It can be argued that the total number of items in a picture is better represented by the "total possible" set of items, rather than the subset actually mentioned by the S. Such an assumption is bolstered by the finding that an average of 13% of an S's recall score consisted of items not mentioned in his description of the picture. An inventory of all items mentioned by any S (excluding different labels for the same items) was constructed for each picture, resulting in a total of 129 items in the Lady pictures and 152 items in the Bus pictures. Recall, expressed as a percent of this inventory, drops to a mean of 14% correct. Neither of the above procedures seems an entirely satisfactory method of estimating amount of recall; at best the two estimates provide upper and lower limits on amount of verbal recall of complex pictures.

Finally, it should be noted that there was a high subject correlation between number of items mentioned in description and in recall, $r = .73$, $p < .01$. Both verbal measures had a low correlation with the Ravens test, $r = .10$, n.s., and .16, $p < .05$ respectively.

Same-Different Recognition Test

Table 2 shows the proportion of correct recognition of the Original picture, each of the transformations, and the total proportion correct. A

Table 2 about here

---

rough correction for possible response bias in saying Same or Different was calculated by multiplying overall rate of saying Same or Different by actual occurrence of same or different pictures. This method resulted in an estimate of chance probability of a hit on the transformations of .48, and chance probability of a hit on the Original of .07. It can be seen from Table 2 that recognition of the Substitution transformation was essentially at chance, with Size and Rearrangement resulting in somewhat higher scores. Recognition was best for Deletion, Reversal, and the Original picture. Overall, probability of correct recognition was .70.

Analyses of variance (3 subject variables x 2 stimulus variables) were carried out on a total recognition score, consisting of the total number of correct recognitions, and separately on the number correct on each transformation. Significance levels for differences among the various groups are also shown in Table 2.

Subject variables. 1) Grade. Grade two had a significantly higher total recognition score than grade one. This difference was primarily due to grade two's higher scores on the reversal and deletion transformations. Thus, grade two showed superior recognition even though there were no differences between the grades on verbal description or recall. 2) Sex. There were no significant differences between total correct or on any transformation between males and females. Again, this result may be contrasted with the results on the verbal measures, in which males showed higher description and recall scores. 3) Ethnic Group. There were no significant differences in total number correct. The only significant difference occurred on the reversal transformation, on which Blacks showed poorer recognition. A Grade by Ethnic Group interaction on this transformation

($p < .01$) indicated that the difference in recognition had disappeared by the second grade. Thus the differences found in description and recall among the ethnic groups were not replicated in the recognition test.

For all three subject variables, verbal description and recall measures were poor predictors of accuracy of recognition. A subject correlation between number of items described and total correct recognition resulted in an r of .21, $p < .01$, and between number of items recalled and total correct recognition, an r of .25, $p < .01$. The correlation between the Ravens test and total correct recognition was .16, $p < .05$.

Stimulus variables. 1) Organization. Total correct recognition was significantly higher for organized pictures. The main transformations involved in this difference were Rearrangement and Size. These two transformations are most directly relevant to the degree of organization of a picture as it has been defined here, namely, as the number of meaningful relationships among the items in the picture. Both the rearrangement and size transformations involve a change in relationships among objects, and these changes were better recognized in the more organized pictures.

The other major difference occurred on the deletion transformation. Deletion of detail was better recognized in the unorganized pictures. Since there were no meaningful relationships between the objects in the unorganized pictures, it is possible that more attention was paid to details of the objects represented. In the organized pictures, on the other hand, more processing of relationships among objects took place. This does not appear to be a question of how Ss spend a limited processing time, since presentation of each picture lasted three minutes, but rather a question of what aspects of organized and unorganized pictures tend to be coded for storage.

2) Picture Set. The Lady pictures were recognized significantly more often than the Bus pictures. It will be recalled that the Lady pictures contained less information, in the sense that they produced less verbal description and has a smaller total inventory of items. Although it has been assumed that high information pictures are easy to recognize because distractors tend to be very different, it is possible that when distractors consist of small changes on the target pictures that recognition is hindered by a greater amount of information. More pictures would have to be studied to test this hypothesis.

There were significant interactions between the Set and Organization variables on the substitution, rearrangement and size transformations. Substitution of the clock was recognized more often than substitution of the fruitbowl, and this difference was most pronounced in the organized version. Rearrangement of the shoes was noticed more often than rearrangement of the jacket, especially in the organized scenes. These differences appear to reflect uncontrolled differences in saliency of various objects in the different pictures, perhaps in part as a function of their location in the picture as well as degree of organization in the picture as a whole. In addition, the size transformation was noticed oftener in the organized Bus picture than in any other. This was the only size change that also changed perspective, since the smaller bus looked farther away in the organized version. This finding suggests that size change is more salient if it involves an apparent third dimensional change in relation to other objects in the picture.

Concerning the relationship between verbal recall and recognition as a function of stimulus variables, only degree of organization affected both

measures. More was recalled about the organized pictures and they were better recognized. These differences in memory were not, however, related to number of words used to describe these types of picture.

Paired-Comparison Test

The Same-Different test showed which transformations were most difficult to recognize, i.e., which were more similar to or confusable with the original picture. The question then becomes whether it is possible to scale distances along a dissimilarity dimension (or dimensions) to aid our understanding of the structure of what is stored in memory. If it is assumed that memory for pictures can be represented as a multidimensional Euclidean space, and that the judged degree of similarity of any transformation to the Original or to other transformations is inversely related to distances within that space, then the Paired-Comparison test can be used to estimate where in that space each transformation of the original picture is located.[3]

The mean percent times that the Original and each transformation was chosen in comparison with every other was computed separately for the various groups and converted to d' scores (a measure of discriminability). Thus matrices of d' scores were formed from the 15 paired-comparisons of each original picture and its five transformations. These matrices give an estimate of the distance each transformation is from each other and from the Original in the hypothetical memory space. To the extent that the Original can be considered as an anchor point in the space (since each paired-comparison was made on the basis of similarity to the Original) the distances from the Original to the transformations can also be considered a measure of distortion of the Original by the particular transformation made.

Independent matrices, each based on 168 observations, were constructed for the two sets of original pictures, for the organized and unorganized versions of the pictures, and for grades one and two. Matrices for the three ethnic groups were based on 112 observations each. The breakdown by sex was not included because of the lack of differences found on the Same-Different test. Each of the matrices was analyzed separately by the TORSCA multidimensional scaling program (Young and Torgerson, 1967).

The Kruskal stress index for each analysis (giving an estimate of goodness of fit of the various points in a given number of dimensions) for one and two dimensional solutions, as well as percent of variance accounted for by the dimensions are shown in Table 3. In all cases except the Chicano

---

Table 3 about here

---

group, the two dimensional solution gave close to perfect fit (stress varying from 0.01% to 0.6%), and even in the Chicano group the fit was excellent (1.6%). For the one dimensional solutions, stress varied from .01% to 10.4%. Since only six items were being compared, the excellent fit in two dimensions might have occurred by chance, although the high degree of similarity among solutions obtained from independent groups of subjects and between different pictures makes such a possibility unlikely. Based on Klahr's (1969) analyses, the probability of obtaining by chance stress indices as low as those in the one dimensional solutions is less than .05 in each case.

The one dimensional solutions were highly similar to the first dimension of the two dimensional solutions, presumably because in both cases one

dimension accounted for most of the variance. Although the one dimensional solutions were adequate descriptions of the data, the two dimensional solutions are presented here, because they give a clearer picture of the data and because work in progress with adults suggests that two dimensional solutions will be necessary. Figure 2 shows the solutions obtained from the various subgroups. For each breakdown the groups being compared are shown in the same space, although they were derived independently. Inspection of Figure 2 shows that in all cases Original is located at one end of the main dimension, and that Reversal is located at the greatest distance from the Original, with Deletion the next farthest from the Original. The other three transformations are located in between, show the most overlap, and the most movement from analysis to analysis. No attempt was made to conceptualize the second dimension since it accounted for relatively little of the variance, although in all cases Deletion was at one end of the dimension and Rearrangement at the other.

Panel 1 shows the comparison between the two types of original picture. There should be a close correspondence between these two TORSCA analyses if we wish to conclude that the pictorial memory space thus constructed is general and not idiosyncratic to a particular picture. Looking at Panel 1 we can see that Original, Reversal, and Deletion occupy roughly the same spaces. The greatest change from one picture to the other occurs on Size and Rearrangement, followed by Substitution. Comparing the movement of these three transformations (toward or away from the Original as a different picture is used) with the proportion of correct recognition for these transformations in the Same-Different test, shown in Table 2, we can see that in each case in which a transformation was recognized less well it is closer

to the original in the TORSCA analyses. As mentioned above, these three transformations seem to have different effects on recognition depending upon the saliency and location of the particular item transformed in a given picture.

Turning to the effects of organization, Panel 2 indicates that the rearrangement transformation was most affected by differences in degree of organization. Rearrangement was less frequently recognized in the unorganized pictures in the Same-Different test, and in the Paired-Comparison test this transformation was judged to be closer to the Original in the unorganized pictures. Thus there is good agreement between the two tests on the greater importance of relationships among objects in organized pictures.

Comparisons between grades one and two are shown in Panel 3. They are very similar to each other on the first dimension. The first graders in fact show essentially a one-dimensional solution, while the second graders' scores have begun to move into the second dimension. Although current work with adults indicates that the second dimension accounts for a still greater part of the variance, more work is needed to conclude that there is a developmental difference in complexity of pictorial memory space.

Panel 4 shows comparisons among the three ethnic groups. The chief conclusion is that the pictorial memory space is highly similar for the three groups. This result confirms the lack of difference among ethnic groups on the Same-Different test.

Overall, there was excellent agreement between the two types of recognition test. The advantage of the Paired-Comparison test is that it gives a more detailed picture of differences between the Original and the transformations. In addition it eliminates response biases such as the tendency to say Same or Different to most pictures, a factor which might

well vary among Ss of different ages. Although a left or right choice bias could exist in the Paired-Comparison test, analyses of the number of times Ss chose the left or right picture indicated that no such bias was operating.

Because the two recognition tests were given in a constant order, it is possible that performance on the Same-Different test influenced choices on the Paired-Comparison test. For example, if a subject correctly recognized a transformation as different, he might be less likely to choose it in the Paired-Comparison test. To check on this possibility, percent choice of each transformation in the Paired-Comparison test was plotted as a function of the number of correct responses on the Same-Different test. Two Ss who made six out of six errors on the Same-Different test were excluded from this analysis. The remaining Ss, grouped according to number correct, are shown in Figure 3. It can be seen that performance on the Paired-Comparison test did not differ as a function of accuracy on the Same-Different test, indicating at least some degree of independence of the two tasks.

Discussion

The present data offer little support for a conception of unlimited pictorial recognition. In spite of long presentation times, overall recognition rate was fairly low (70%) and varied from chance responding to 91% correct depending upon the nature of the distractor. All the distractors used in this experiment were minor transformations on the original pictures and thus were similar to the target pictures. Conflicting results have been reported when similar distractors have been used, some studies finding lower recognition rates, some not. The question then becomes how to define and scale similarity of complex pictures which contain many visual and semantic dimensions.

The multidimensional scaling method used in this experiment appears to be a useful technique for scaling the similarity of distractors to the picture stored in memory, and in addition to discover which aspects of pictures are most likely to be retained. Not only were transformations on the target pictures stably located in a memory space, but changes within that space were related to type of picture and the degree of organization within pictures. For example, the judged similarity of a given distractor differed as a function of amount of organization in the stimulus materials.

There was a very close correspondence between the two types of recognition tests, even though they asked for different judgments. In the Same-Different test, the subject was asked whether he had seen a picture before, and in the Paired-Comparison test he was required to make a similarity judgment. Although it has been assumed here that similarity of distractor to target is a major factor in recognition accuracy, it should be pointed out that this assumption needs further testing. In the first place, similarity judgments may differ when they are made in the presence of the target items than when they are made about remembered targets. Second, it could be the case that reversal of a picture, for example, is easy to recognize as different yet be judged most similar to the original on the grounds that all the relationships among the objects are the same. The fact that recognition and similarity judgments were highly correlated for children does not necessarily mean that the same relationships will hold for adults. This problem is currently being investigated.

Two of the transformations were consistently recognized across pictures and also judged as most dissimilar, namely, Reversal and Deletion of detail. Although experiments with adult subjects have typically found only slight

loss in recognition accuracy when reversals were used (Dallett et al, 1968; Standing et al, 1970), the .91 rate of recognition of reversals in this experiment seems surprising in light of a number of studies showing that children have difficulty in discriminating among reversals of pictorial geometric forms (e.g., Rudel and Teuber, 1963). Ease in recognizing reversals in more complex pictures may be a function of the total number of items whose location is changed. In the present experiment, reversal involved a greater number of locational changes than any other transformation. On the other hand, recognition of reversals may be a function of the meaningfulness of the material used. Current work is being done to evaluate these possibilities.

The other transformation most consistently recognized as different was deletion of detail. This result is consistent with experiments reported by Vurpillot (1972), showing that children of age seven are better at detecting differences in detail in meaningful pictures than size changes or rearrangement. On the other hand, her experiments indicated that children of this age are also good at detecting small substitutions, a result at variance with the present data. It should be pointed out, however, that Vurpillot's work like that of Gibson, Gibson, Pick and Osser (1962), involved detection of differences in a matching-to-sample task. Little is known about attentional or search patterns in detection vs. memory tasks, nor whether the differences easiest to detect are those which are most often retained in memory.

Concerning the relationship between verbal measures and recognition in the present experiment, for the subject variables verbal measures were poor predictors of accuracy of recognition. The stimulus variables, however, showed two types of relationship between verbal and visual measures. The pictures which contained more information (had a higher inventory of items)

called forth more words in description and were also more difficult to recognize. Thus there was a negative relationship between amount contained in a picture and amount remembered.

On the other hand, the organized and unorganized versions of the pictures, which contained equal numbers of items and called forth the same number of words in description, nevertheless showed differences in both recall and recognition as a function of degree of organization. Thus, amount of organizational or structural information showed a positive relationship with amount remembered. Finally, it should be noted that an hypothesis that equates amount of organization with number of words used in description, such as the verbal-loop hypothesis (Glanzer and Clark, 1964), is not a useful equation in the type of pictorial recognition studied in this experiment.

References

Bahrick, H. P. & Boucher, B. Retention of visual and verbal codes of the same stimuli. Journal of Experimental Psychology, 1968, 78, 417-422.

Bahrick, H. P., Clark, S., & Bahrick, P. Generalization gradients as indicants of learning and retention of a recognition task. Journal of Experimental Psychology, 1967, 75, 464-471.

Borges, M. A. Increasing item accessibility in free recall. Journal of Experimental Psychology, 1972, 95, 66-71.

Brooks, L. R. The contribution of verbal descriptions to visual memory in nursery-school children. Unpublished Project Report for U.S. Office of Education, 1971.

Brown, A. L. & Campione, J. C. Recognition memory for perceptually similar pictures in preschool children. Journal of Experimental Psychology, 1972, 95, 55-62.

Brown, A. L. & Scott, M. S. Recognition memory for pictures in preschool children. Journal of Experimental Child Psychology, 1971, 11, 401-412.

Dallett, K., Wilcox, S. G., & D'Andrea, L. Picture memory experiments. Journal of Experimental Psychology, 1968, 76, 312-320.

Daniel, T. C. Nature of the effect of verbal labels on recognition memory for form. Journal of Experimental Psychology, 1972, 96, 152-157.

Garner, W. R. Uncertainty and structure as psychological concepts. New York: John Wiley and Sons, 1962.

Gibson, E. J., Gibson, J. J., Pick, A. D., & Osser, H. A developmental study of the discrimination of letter-like forms. Journal of Comparative and Physiological Psychology, 1962, 55, 897-906.

Glanzer, M. & Clark, W. H. The verbal-loop hypothesis: Conventional figures. American Journal of Psychology, 1964, 77, 621-626.

Goldstein, A. G. & Chance, J. E. Visual recognition memory for complex configurations. Perception & Psychophysics, 1970, 9, 237-241.

Haber, R. N. How we remember what we see. Scientific American, 1970, 222, 104-112.

Harrington, L. F. & Brown, D. R. Visual pattern perception: Multidimensional analysis of discrimination difficulty for children. Psychonomic Science, 1972, 29, 219-221.

Heider, E. R. Style and accuracy of verbal communication within and between social classes. Journal of Personality and Social Psychology, 1971, 18, 33-47.

Henley, N. M. A psychological study of the semantics of animal terms. Journal of Verbal Learning and Verbal Behavior, 1969, 8, 176-184.

Jensen, A. R. The role of verbal mediation in mental development. Journal of Genetic Psychology, 1971, 118, 39-70.

Klahr, D. A Monte Carlo investigation of the statistical significance of Kruskal's nonmetric scaling procedure. Psychometrika, 1969, 34, 319-330.

Mandler, G., Pearlstone, A., & Koopmans, H. S. Effects of organization and semantic similarity on recall and recognition. Journal of Verbal Learning and Verbal Behavior, 1969, 8, 410-423.

Nelson, K. E. Memory development in children: Evidence from nonverbal tasks. Psychonomic Science, 1971, 25, 346-348.

Rosinski, R. R. The development of attention and recognition. Unpublished doctoral dissertation, Cornell University, 1970.

Rudel, R. G. & Teuber, H. L. Discrimination of direction of line in children. Journal of Comparative and Physiological Psychology, 1963, 56, 892-898.

Shepard, R. N. Recognition memory for words, sentences, and pictures. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 156-163.

Standing, L., Conezio, J., & Haber, R. N. Perception and memory for pictures: Single-trial learning of 2500 visual stimuli. Psychonomic Science, 1970, 19, 73-74.

Vurpillot, E. Le monde visuel du jeune enfant. Paris: Presses Universitaires de France, 1972.

Young, F. W. & Torgerson, W. S. TORSCA, A FORTRAN IV program for Shepard-Kruskal multidimensional scaling analysis. Behavioral Science, 1967, 12, 498.

Footnotes

1. This research was supported in part by a grant from the San Diego Unified School District to the authors, and in part by USPHS grant MH-15828 to the Center for Human Information Processing, University of California, San Diego. Responsibility for authorship is equally shared. We would like to thank George Mandler and participants in a research seminar at University of California, San Diego for many creative suggestions during the course of this research.

2. Reprint requests should be sent to Jean M. Mandler, Department of Psychology, University of California, San Diego, La Jolla, California 92037.

3. An example of a similar type of analysis used to explore the structure of semantic, rather than pictorial, space can be found in Henley (1969), and for discriminability of letter-like forms in Harrington & Brown (1972).

Table 1

Verbal Description and Verbal Recall Measures

		Description			Recall				
		No. of items	Inferential + relational statements	No. of Repetitions	No. of items	Inferential + relational statements	No. of Repetitions	% of description recalled	% of recall not in description
Total:	N = 336	32.4	1.8	4.4	19.4	1.2	2.7	53.5	12.6
Grade:	One	31.1	1.8	4.8	18.1	1.3	2.9	53.4	11.8
	Two	33.8	1.7	3.9	20.7	1.0	2.5	53.6	13.4
Sex:	Male	34.3 **	2.1 ***	4.7	21.0 ***	1.4 *	3.0	53.4	13.6
	Female	30.6	1.5	4.0	17.8	0.9	2.5	53.5	11.5
Ethnic:	Anglo	36.1 ***	2.2 ***	4.4 *	21.1 *	1.4 *	2.9 **	53.1	12.2
	Black	32.1 ***	2.1 ***	6.1 *	19.4 *	1.4 *	3.2 **	53.0	13.0
	Chicano	29.0	1.1	2.6	17.7	0.7	2.1	54.3	12.5
Organization:	Organized	32.0	1.8	4.4	20.8 **	1.4	3.0	57.0 ***	13.7 *
	Unorganized	32.9	1.8	4.4	18.0	1.0	2.4	49.9	11.5
Set:	Lady	30.8 *	2.2 ***	4.5	19.1	1.5 ***	3.0	55.4 *	11.3 *
	Bus	34.0	1.4	4.2	19.8	0.8	2.5	51.6	13.8

* = $p<.05$
** = $p<.01$
*** = $p<.001$

Table 2

Proportion Correct on Original Pictures and Five Transformations in Same-Different Recognition Test

Transformations		ORIG	SUB	SIZ	REA	DEL	REV	TOTAL
Total:	N = 336	.89	.49	.58	.59	.77	.91	.70
Grade:	One	.92	.45	.54	.55	.68	.87	.67
	Two	.86	.53	.61	.62	.86 **	.95 *	.74 *
Sex:	Male	.87	.50	.58	.57	.77	.92	.70
	Female	.91	.48	.57	.61	.77	.90	.71
Ethnic:	Anglo	.88	.52	.58	.62	.76	.96	.72
	Black	.87	.50	.59	.59	.77	.86 **	.69
	Chicano	.92	.45	.56	.54	.79	.91 **	.70
Organization:	Organized	.91	.51	.62 **	.64 **	.71 **	.93	.72 ***
	Unorganized	.87	.47	.53	.54	.84	.89	.69
Set:	Lady	.91 *	.61 ***	.52	.73 ***	.80 *	.93	.75 ***
	Bus	.87	.37	.64	.45	.74	.88	.66

* = $p<.05$
** = $p<.01$
*** = $p<.001$

Note: The following abbreviations are used in Table 2 and in Figure 2: original--ORIG, substitution--SUB, size change--SIZ, rearrangement--REA, deletion--DEL, reversal--REV.

Table 3

Percent stress and percent of variance accounted for by each dimension in one and two dimensional solutions

		Two dimensional Solutions			One dimensional Solutions	
		Stress	Variance		Stress	Variance
			1st dimen	2nd dimen		
Set:	Lady	0.01	79.8	20.2	0.01	100.0
	Bus	0.12	90.2	9.4	0.01	100.0
Organization:	Organized	0.56	89.3	9.6	10.40	87.0
	Unorganized	0.05	89.1	10.9	5.07	91.4
Grade:	One	0.01	93.8	6.2	0.01	100.0
	Two	0.01	85.8	14.2	9.52	83.1
Ethnic:	Anglo	0.01	90.4	9.6	0.01	100.0
	Black	0.03	93.6	6.4	6.10	90.2
	Chicano	1.61	89.5	8.2	6.67	92.2

Figure Legends

Figure 1. Organized and unorganized versions of two pictures.

Figure 2. Two dimensional TORSCA multidimensional scaling analyses derived from independent groups of subjects and different types of stimuli. Panel 1 compares the two types of picture. Panel 2 compares organized vs. unorganized versions of the pictures. Panel 3 compares two grade levels, and Panel 4 three ethnic groups. Stress indices are given in Table 3.

Figure 3. Percent choice of each transformation in the Paired-Comparison test plotted as a function of number of correct responses on the Same-Different test. Number of subjects involved in each point is shown below the abscissa.

Figure 1

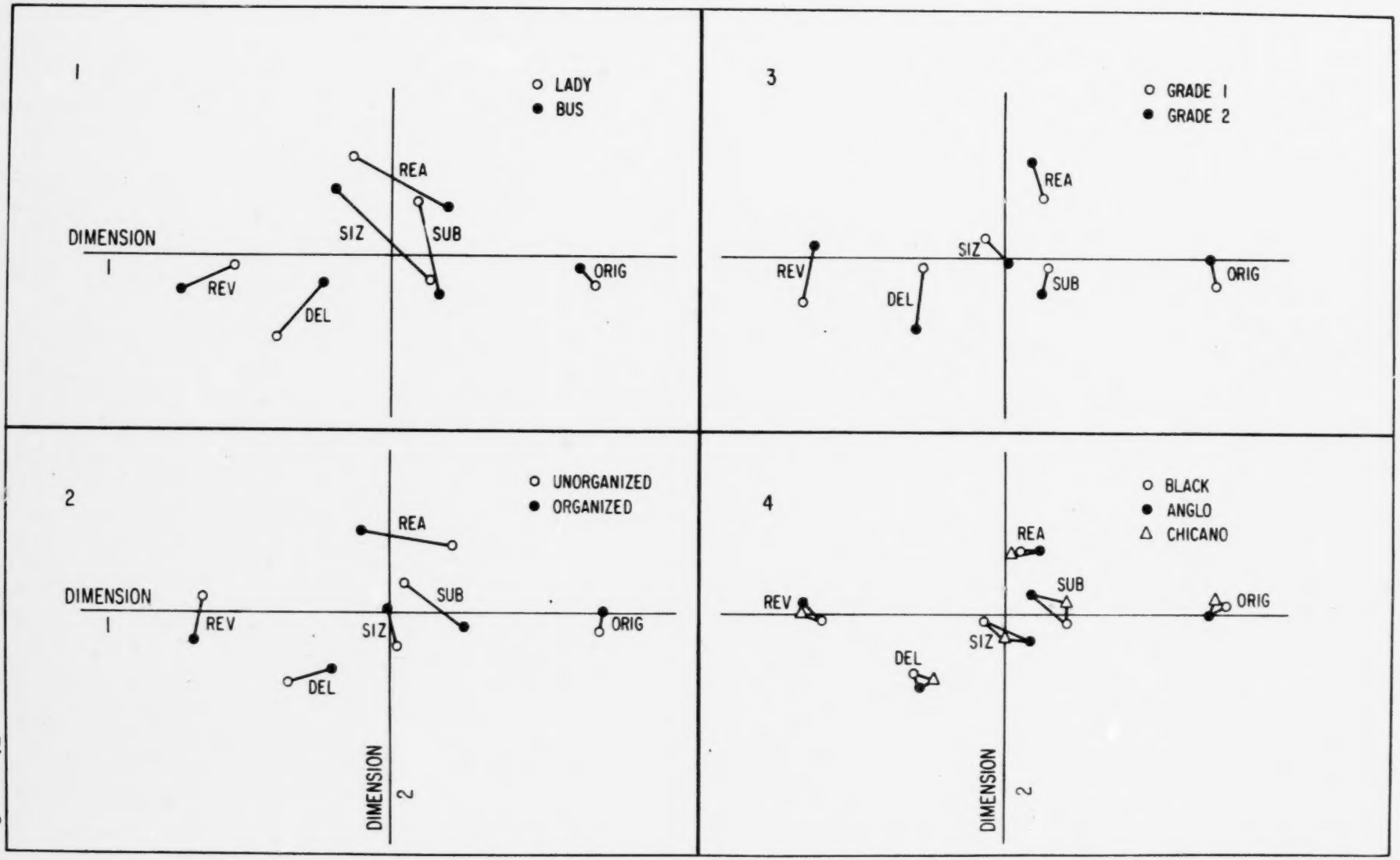
1
LADY
BUS
REA
SIZ
SUB
DIMENSION
1
REV
DEL
ORIG
3
GRADE 1
GRADE 2
REA
SIZ
REV
DEL
SUB
ORIG
2
UNORGANIZED
ORGANIZED
REA
DIMENSION
1
SUB
REV
SIZ
ORIG
DEL
DIMENSION
2
4
BLACK
ANGLO
CHICANO
REA
SUB
REV
ORIG
SIZ
DEL
DIMENSION
2

Figure 2

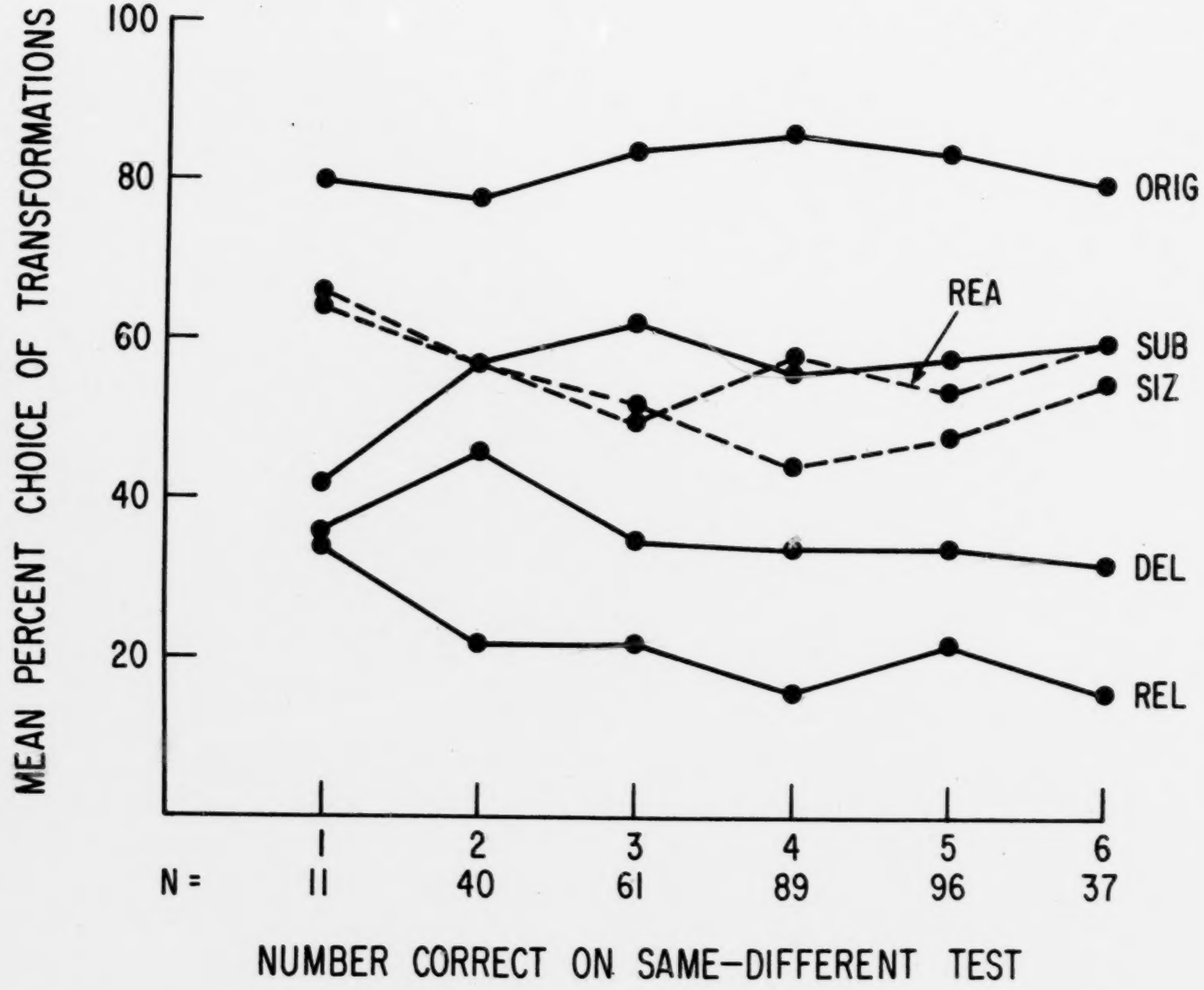
MEAN PERCENT CHOICE OF TRANSFORMATIONS
100
80
60
40
20
ORIG
REA
SUB
SIZ
DEL
REL
1
2
3
4
5
6
N =
11
40
61
89
96
37
NUMBER CORRECT ON SAME–DIFFERENT TEST

Figure 3